RESEARCH TESTS & RESULTS of Genano air Decontamination Solutions

genano

genano
Pure Air. Nothing Else.

Dear reader,

You are holding collection of research report of genano healthcare air decontamination solutions, that were conducted by a various independent research centers worldwide. The reports explain in detail the performance of genano air decontamination units, as well as the purpose of the research was conducted for.

These researches were conducted in healthcare facilities, laboratories, or in research centers, such as vtt, a technical research centre of finland; a government owned and controlled non-profit research center in finland.

These reasearch tests are divided into two main research areas:
1. Nanoscale particle purification
2. Elimination of microbes

The tests are conducted by using the same genano technology with a different types of air decontamination Units. More detailed information about research methods is explained in each report.

We are hoping this publication offers you the required information about genano cold plasma technology, that can address even the most challenging air purification needs, ranging from battling against spread of infectious diseases in healthcare facilities' isolation wards, protective environment rooms, bone marrow transplantation, haematology, oncology, organ transplantation - to ensuring decontaminated environment for ivf, laboratories, clinics, scientific research, dna diagnostics and other critical areas.

Scientific Study:

Effect of Electronic Filtration

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Effect of Electronic Air Filtration Technology on Air Quality in Operation Rooms (Cairo-Egypt)

Mossad I.M.*, El Awady M.Y.*and Nagwa M Abo ElMagd.**
*Department of Community, Environmental, and Occupational Medicine. Faculty of Medicine, Ain Shams University.
**Department of Microbiology and Immunology. Faculty of Medicine, Ain Shams University.
Corresponding author: ***Mossad I.M.*** (Isis Magdy Mossad Shehata)

Abstract:
Background: *Hospital environmental control procedures can be an effective support in reducing health care associated infections.* ***Aim:*** *Assessment of the effectiveness of electronic air filtration (A novel air filtration device) in improving air quality in operating room of pediatric surgery department, Ain Shams University Hospitals.* ***Methodology:*** *This study was divided into 2 phases, Phase I: Descriptive study: assessment of air quality in operating rooms at pediatric surgical hospital, the evaluated air quality indices were: suspended particulate matter, culture media and microbial identification of bacteria and fungi using active and passive air sampling. Phase II: Interventional study for improving air quality by new electronic air decontamination unit (Genano® 4500).* ***Results:*** *After intervention the operation room moved up from (ISO 8) to (ISO 6) there is a highly statistical significant difference between particulate matter count before and after intervention also there is significant difference in active bacterial sampling and fungi sampling before and after applying electric filtration device where fungal colony count dropped significantly to zero. All virulent bacterial species as E.Coli, klebsiellaspecies and Pseudomonas Aeroginosa. disappeared from sample with few micrococci and bacillus species were preset in few samples.* ***Conclusion:*** *the importance of electronic filtration as an effective method to improve air quality in OR, hence reducing morbidity and subsequent mortality that could occur to the patients due to poor air quality in the operating theaters.*
Keywords: *Air quality, Electronic filtration, Microbiological air sampling, Operating rooms.*

Introduction:

Surgical site infection (SSI) is one of the most common Healthcare Associated Infection (HAI), estimated to account for 18.6% of inpatient HAI (Berriós-Torres *et al.*, 2017)

In Egypt, A study was carried out on 292 patients recruited from those admitted to the General Surgery Department of Tanta University Hospital for elective surgery during a period of 6 months. The patients were examined for the development of SSI during the postoperative hospital stay showing overall incidence of SSI of 22.6% (Afifi *et al.*, 2009).

In 11 Egyptian hospitals, 510 surgical site infections (SSIs) following 4246 surgeries were identified with overall SSI rate of 12%. SSI rates

2015 Oman Royal Hospital
Customer evaluation of Genano 4500

Royal Hospital

Infection Prevention & Control

Summary of Genano Mobile Filter Evaluation (SNW)

Date	Room No.	Pre-filter	24 Hours post filter	48 hours post filter
15.12.2014	7	Bacteria: heavy growth Fungus:> 50 cfu/m^3	Bacteria:17 cfu/m^3 Fungus: 0 cfu/m^3	(72 hours sample) No Bacterial & Fungus Growth
22.12.2014	14	Bacteria: 100 cfu/m^3 Fungus: 0 cfu/m^3	Fungus: 0 cfu/m^3 Bacteria: 0 cfu/m^3	No Bacterial & Fungus Growth
29.12.2014	2	Bacteria: 44 cfu/m^3 Fungus: 1 cfu/m^3	No Bacterial & Fungus Growth	No Bacterial & Fungus Growth
12.1.2015	8	Fungus: 4 cfu/m^3 Bacteria: 90 cfu/m^3	No Bacterial & Fungus Growth	No Bacterial & Fungus Growth
1.2.2015	5	Bacteria: 4 cfu/m^3 Fungus: 0 cfu/m^3	No Bacterial & Fungus Growth	No Bacterial & Fungus Growth

DR. ZAINAL MASKARI
SENIOR SPECIALIST
INFECTION PREVENTION & CONTROL
ROYAL HOSPITAL
4/3/15

Elimination of microbes

MetropoliLab

13.5.2014

REPORT

The performance of Genano ® air purifier at the elimination of microbes suspended into the surrounded indoor air

MetropoliLab is a laboratory enterprise owned by the cities of Helsinki, Espoo, Vantaa and Kauniainen. It is an impartial, independent laboratory accredited by Finnish Accreditation Service. The laboratory methods used are approved by authorities in Finland.

Procedure

Genano ® air purifier 310 was placed in a laboratory room and the air was artificially contaminated with four different microbe strains (target organisms).
The contamination was achieved by fanning a reservoir of a lyophilized microbe preparation for three hours. During that time Genano ® air purifier 310 was in function.
Microbial sampling took place after this contamination period of time.

Target organisms

used for contamination of the air
Staphylococcus aureus
Bacillus cereus
Saccharomyces cerevisiae
Streptomyces–strain

The concentration of target organisms in the lyophilized preparation was between 2 x10^2 -10^5 cfu/g and the total amount used for contamination was 3 g.

Sampling

After 3 hours period of verified indoor air contamination sampling was performed:

1) 10 x 10 cm piece of sterile cotton cloth was placed against the inner side of the air filter during the air contamination period and its concentration of the target organism after the contamination was performed.
2) After contamination the equipment was washed according to the instructions. The washing liquid was run into a sterile vessel and its concentration of the target organisms was performed. Before analyzing the liquid was neutralized.

Microbiological methods

Staphylococcus aureus	Blood agar, 37^{0}C, 24 h
Bacillus cereus	Blood agar, 37^{0}C, 24 h
Saccharomyces cerevisiae	2 % malt extract agar, 25^{0}C, 7 d
Streptomyces	Tryptone yeast extract glucose agar, 25^{0}C, 7 d

Address
Viikinkaari 4
00790 Helsinki
Tel
010 3913 50
metropolilab@metropolilab.fi
http://www.metropolilab.fi

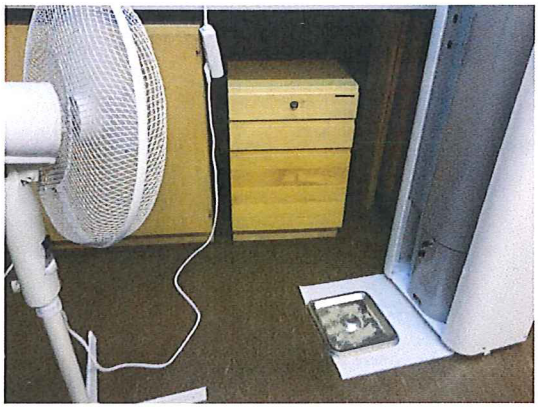
MetropoliLab

13.5.2014

Results

Concentration of target organims (cfu) after 3 hours of indoor air contamination procedure		
Target microbe	Filter *) /100 cm^2	Washing liquid/ml
Staphylococcus aureus	<5	0
Bacillus cereus	<5	0
Saccharomyces cerevisiae	<5	0
Streptomyces	<5	0

*) Detection level/100 cm^2 is 5 cfu



Picture 1.
Lyofilized preparation of four target organisms on a tray was used to contaminate the air.

Picture 2. A sterile cloth was touched to the inner surface of the filter to collect all possible out coming organisms. The cloth was cultured for the determination of target organisms.

Address
Viikinkaari 4
00790 Helsinki
Tel
010 3913 50
metropolilab@metropolilab.fi
http://www.metropolilab.fi

MetropoliLab

13.5.2014

Picture 3. The washing liquid of the purifier after the use for purifying the air artificially contaminated with different microbes. The liquid was cultured for the determination of target organisms.

MetropoliLab Ltd

Seija Kalso, CEO, microbiologist
Viikinkaari 4
00790 Helsinki

Address
Viikinkaari 4
00790 Helsinki

Tel
010 3913 50

metropolilab@metropolilab.fi

http://www.metropolilab.fi

Measurement of the kinetics of microbiological decontamination

GENANO 310

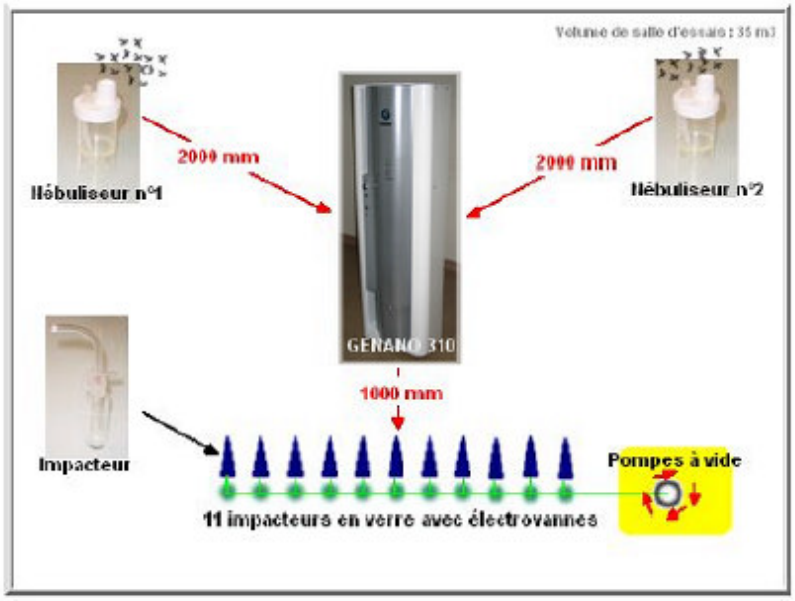
Laboratoire National d'Essai (LNE) – Paris July 2005

Extract from Dossier F020270 – Document CM/1

LNE
Le progrès, une passion à partager

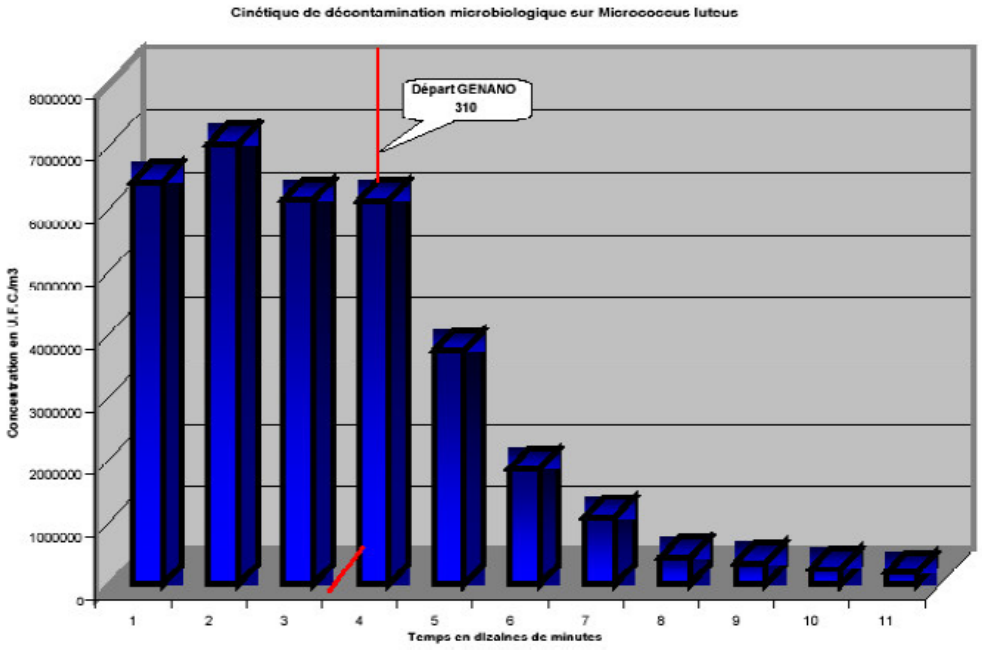
Test protocole

- 35 m3 hermetic room (ISO 2)
- 2 microorganisms diffusers
- 11 receptors



Kinetics of decontamination for bacteria gram + :

. Bacteria : Micrococcus luteus
. Incubation environment: Tryptone soja agar
. Incubation temperature : 37 °C
. Incubation period : 24/48 hours

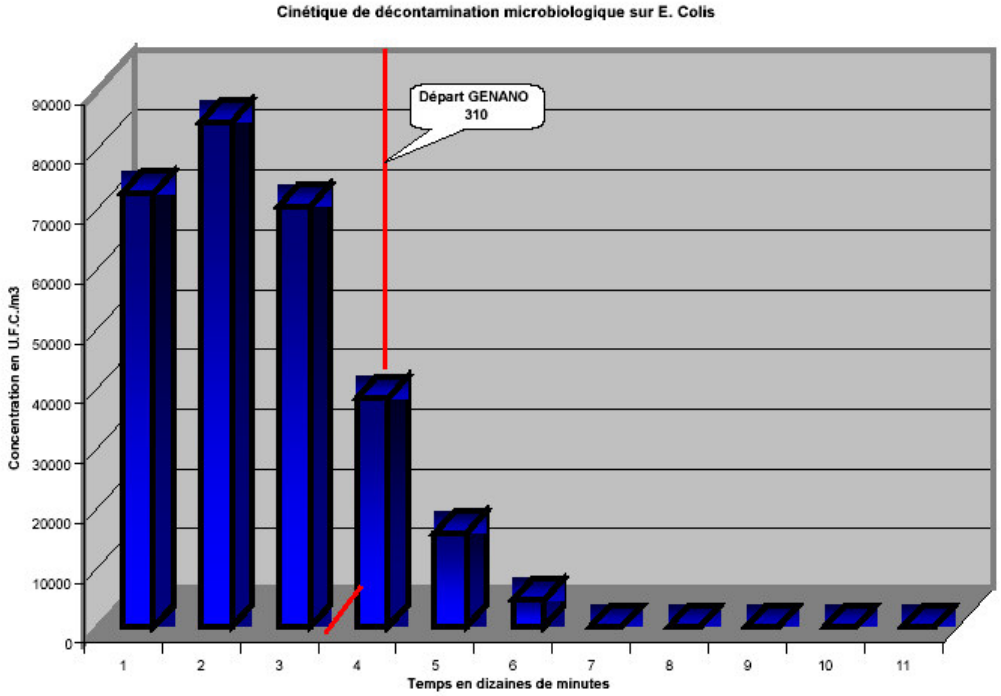


→ Reduction of the population between 10^{-1} and 10^{-2}

Extract from Dossier F020270 - Document CM/1

Kinetics of decontamination for bacteria gram - :

. Bacteria: Escherichia coli
. Incubation environment : TBX
. Incubation temperature : 44 °C
. Incubation period : 24/48 hours

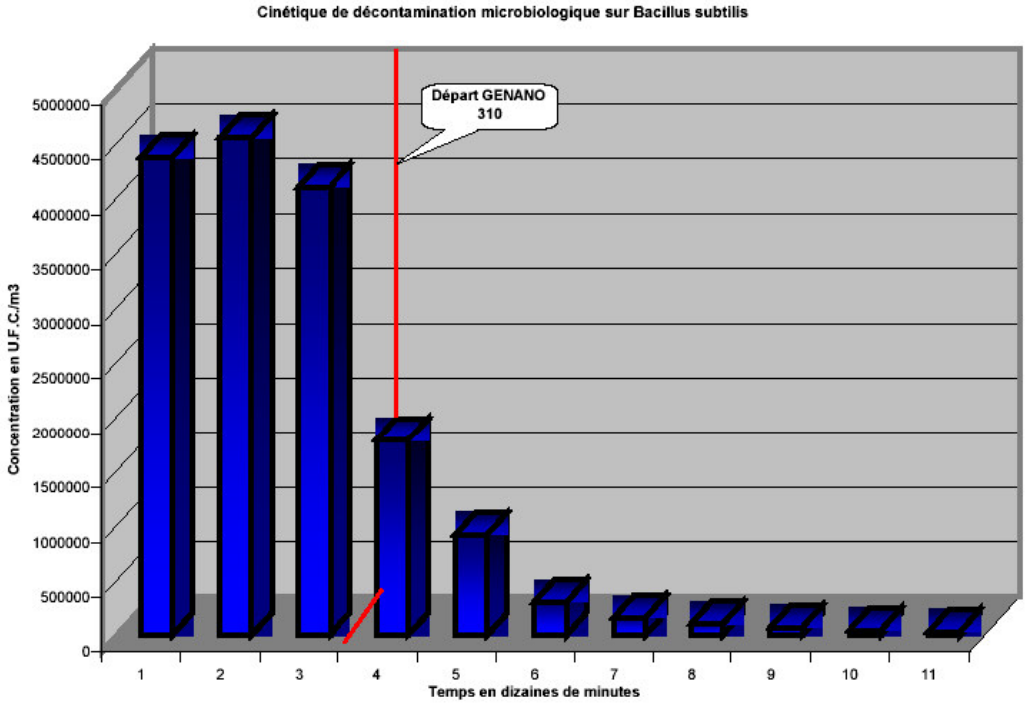


→ Removal of all population in less than 40 min

Extract from Dossier F020270 - Document CM/1

Kinetics of decontamination for bacteria gram - sporulated :

. Bacteria : Bacillus subtilis *var. niger* (sporulated form)
. Incubation environment : Tryptone soja agar
. Incubation temperature : 37 °C
. Incubation period : 24/48 hours

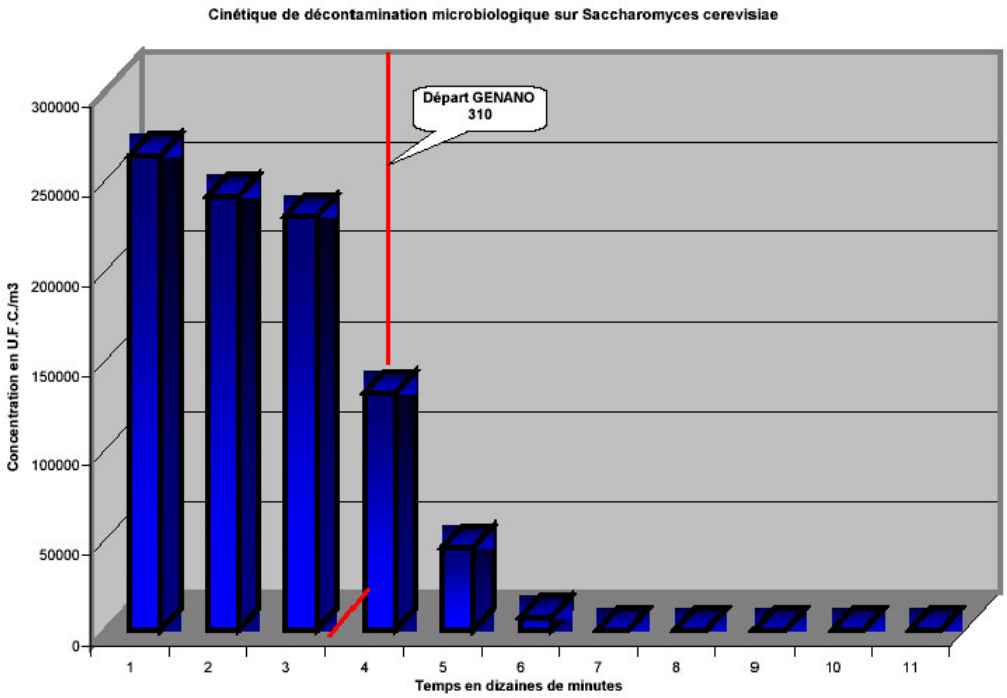


→ **Reduction of the population of 10^{-1}**

Extract from Dossier F020270 - Document CM/1

Kinetics of decontamination for yeasts :

. Yeast: Saccharomyces cerevisiae
. Incubation environment : Gélose Sabouraud
. Incubation temperature : 24 °C
. Incubation period : 72 hours

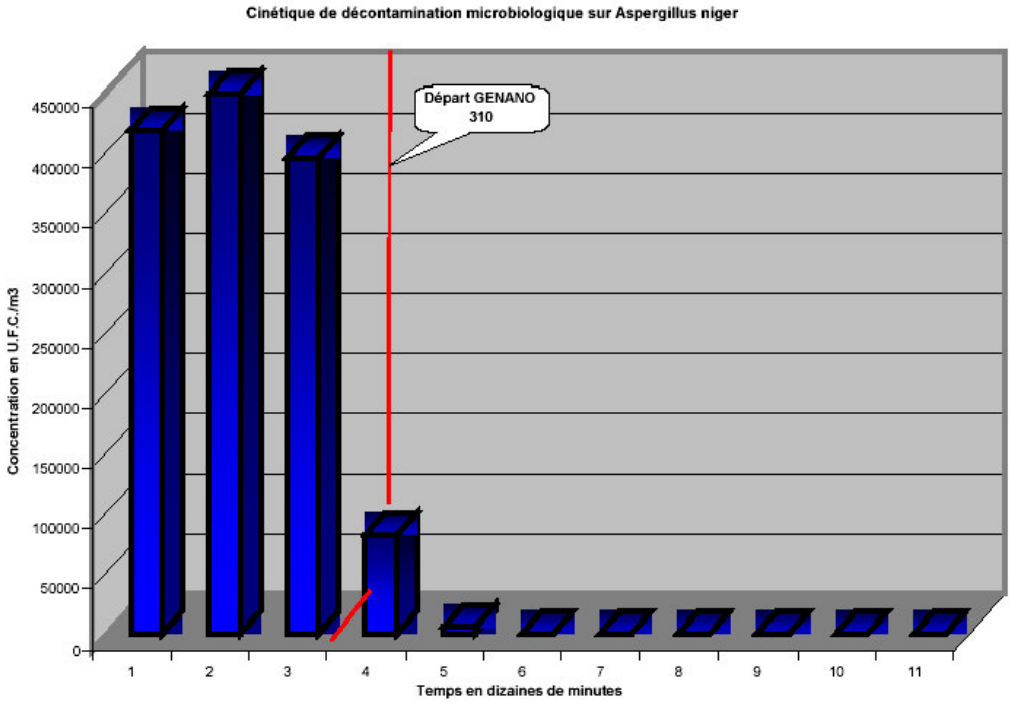


→ **Removal of all population in less than 40 min**

Extract from Dossier F020270 - Document CM/1

Kinetics of decontamination for bacteria gram + :

. Bacteria : Aspergillus Niger
. Incubation environment: Gelose Sabouraud
. Incubation temperature : 24 °C
. Incubation period : 72 hours



→ **Removal of all population in less than 30 minutes**

Extract from Dossier F020270 - Document CM/1

INTERPRETATION OF THE RESULTS

- The decontamination action of the GENANO 310 can vary according to the type and composition of the microorganism's membrane.

- The microorganisms that have a simple membrane are very sensitive to the cleaning action of the GENANO 310. The entire population of bacteria Gram-, yeast and mold was removed in less than 40 min.

- The Bacillus subtilis spores and bacteria gram+ are more resistant because of their membrane composition. Indeed, the Bacillus Subtilis has the ability to alter itself to

  resist attacks from the environment such as temperature, pressure, lack of food, etc. The bacteria Gram+ also has a higher resistance due to its double membrane.

  However, we notice a significant reduction of the population of these microorganisms between 10^{-1} and 10^{-2} in 1 hour.

Extract from Dossier F020270 - Document CM/1

2004 Karol Marcinkowski University of Medical Sciences microbial decontamination

P1531

New way of microbe decontamination from air - MFI method

Z. Muszyñski, I. Mirska
Poznan, PL

Objectives: In many branches of medicine, the microbiologically clean air is a significant condition either of microbial pollution or infection reduction, i.e. in operating place, or medical staff infections.

Methods: The MFI method (Multifunction Ion Air Cleaning) of Genano Oy, Finland was examined, using Nanobio E310 device, from the point of its air decontamination efficiency. Tested device work parameters are: cleaning capacity 250 m^3/h, at air flow velocity 0.5 m/s. The microbiological purity of exhausted air was measured. Two methods were applied for qualitative and quantitative tests; De Ville Biotechnology (MicroBio device), and contact plates method (Oxoid). There were 10 test bacterial and fungal types from ATCC collection (Rockville, USA). In quantitative tests, a microbial suspension (aerosol) was used, density 10 6--10 8 cfu/ml, aseptic conditions.

Results: Microbiological purity of air, after passing through the air cleaning MFI device, determinated the removing and destroying of both bacteria and fungi from air. It is to be highly effective towards a wide spectrum of microbes. The extent of microbiological air contamination does not influence effectiveness of air cleaning with the MFI method. Long-term (7 days) work of Nanobio E310 device does not result in any changes in efficiency of air cleaning with the MFI method, even in conditions of high microbiological pollution of internal air. Research done in experimental conditions, points out to significant microbes reduction in cleaned air. It appears to be at least 10% bacteria and fungi less than in the beginning of the test, what equals effectiveness 99.999% at particles range equal or more than 0.003 μm.

Conclusions: The application of MFI technology, regarding appropriate assembling of air cleaning devices and preserving the air exchange frequency, adequate to room cubature, equipment and number of employees, enable reaching at least B air class of microbial purity (< 10 cfu/m^3 of air) and/or 100, M3.5 air class, ISO 5 according to the United States Federal Standard 09 E and ISO standards as well.

NEW WAY OF MICROBIOLOGICAL DECONTAMINATION OF AIR – MFI METHOD

Zygmunt Muszyński and Ilona Mirska

Karol Marcinkowski University of Medical Sciences, Poznań, Poland

INTRODUCTION

The air polluted with microorganisms can constitute a danger in many fields of human activities, either for health or the quality of produced goods and materials. Effectiveness of applied decontamination methods is particulary important in medicine, in order to reach an appropriate level of biological safety BSL (Biological Safety Level). The quality of mechanical air filtration used so far (HEPA, ULPA, absolute filters – EU 9-13), depends on permeability of a fiber input, which is applied (1,3). MFI method (Multifunction Ion Air Cleaning) does not create such limits. In this one there are two co-operating processes used; ionization and electrostatic attraction of particles (4). MFI method allows removing of particles (size over 0,003 µm) from polluted air. The basic rule of this new method is negative charging of all the chemical, mechanical and biological pollutions. Finally ionized particles are collected on surfaces of positively charged electrodes.

MATERIAL AND METHODS:

1. Air decontamination device:

The effeciency of microbiological air cleaning using MFI method was examined on example of Nanobio E 310, www.wpip.pl; e-mail:office@wpip.pl, air volume – 250 m^3/h, air velocity 0,5 m/s representing the MFI technology. The way the device works is presented in Figure 1,2 and 3.

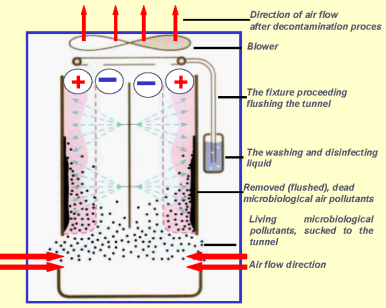


Figure 1.
The draft of microbiological air cleaning proccess, with use of MFI method. Precipitation of microbiological pollution removed from air on inner surfaces of tunnel.

2. Examination of microbiological air quality:

There were two measurements undertaken regarding quantity of removed microorganisms; before and after setting up the MFI air cleaning process. The examination was made in a closed, aseptic room, during a constant, undisturbed work of device. The air was contaminated with test microorganisms exactly at the suction part of device (the input of air) Figure 1,2. The inoculum was spread in the air with atomizer, in four identical portions, two to one every of two Nanobio E 310 inputs.

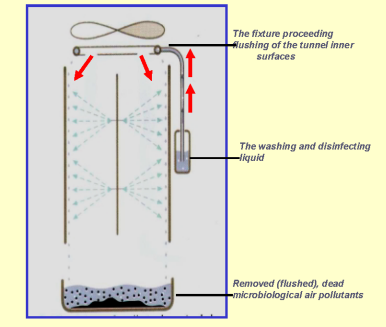


Figure 2.
The proces of decontamination (flushing) tunnel surfaces, removing microbiological pollutions.

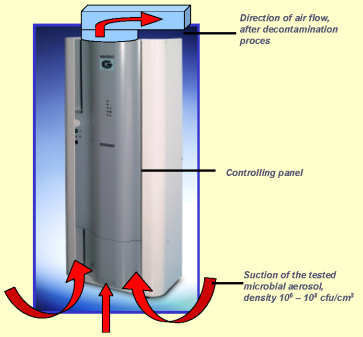


Figure 3.
The picture o Nanobio E 310 air cleaning device and a draft of air decontamination

The quality of cleaned air was measured at the exhaust of air (upper part of the device), near the inputs and in the room space, 1 meter above the ground level. The places of sampling are presented in the Figure 3.
For each of test bacteria there were five measurements made; first in the time of polluting the air (0), next after a quarter, 1, 3 and 24 h starting with the moment of spreading inoculum. The period of measurement depended on method and location of sampling. The examination was made using either quantitative, or semi-quantitative method.

Quantitative method:

Air samples were taken using Microbio apparatus (De Ville Biotechnology) and some contact plates (Oxoid) [Contact Plate – Caso – Agar TSA with disinhibitor (CA), Contact Plate Sabouraud – Glucose Chloramphenicol Selective Agar (SA.)]. For each bacterial strains there were three measurements made, each in sampling period F, according to the producer`s indications (sampling period: 320 sec.; volume of sucked air: 0,48m^3). Plates with medium were incubated for 5 days in temp. 35^{0}C (CA) and 25^{0}C (SA.).
The amount of microorganism cfu/m^3, was calculated on total number of colonies, knowing the air volume taken by the apparatus.

Semi – quantitalive method:

Perti plates, diameter 9 cm, with (TSA), (bioMerieux), (SA.) (bioMerieux) were located in sampling places A and B, for exposition time 60 min:
A – at the air inputs (suction) of device
B – 1 m above the ground level
In the plates the quantity of colonies was estimated (cfu that have grown on plates, after incubation time).

3. Test microorganisms:

Test strains ATTC (Rockville USA) were preserved in Microbank sets, in –70^{0}C, PRO – LAB Diagnostics. The bio-aerozol prepared from the suspension of original culture of bacterial calibrated for 10^6 – 10^8 cfu/cm^3.

4. Preparation of test bacterial and fungal (N) suspension:

Test strains from original culture were cultured on agar TSA or SA and were incubated for 24 hours in temp. 37^{0}C (first and second passage). In order to prepare the test suspension the eyelet of cultured colony was transferred with loop to a flask of 100 ml volume. It contained 5g of glass bulbs and 10 ml of diluting liquid. All was shaken in mechanical shaker for 3 minutes. The suspension from the flask, was separated from bulbs and moved to second aseptic vessel. The expected density in Mac Farland classification of suspension was reached using diluting liquid. The mistiness was measured with use of densitometr (Denzimat, bioMerieux). There was bacterial suspension 10^7-10^8 cfu/cm^3, Candida albicans suspension 3,2x10^7 cfu/cm^3 and conidiosporia of the Aspergilus niger 2,4x10^6 cfu/cm^3 used in examination.

5. Examination of microbiological cleanness of the inner tunnel of device:

For this examination there was a swab method applied. The swabs were taken from the standard surface of 25 cm^3 of inner air cleaning tunnel of device.

Collected material was immediately cultured on a medium (TSA, SA) and liquid medium TSB. Plates were incubated for 5 days in temp. 35^{0}C (bacteria) and 25^{0}C (fungi), and the amount of cfu / 25 cm^2 surface was determinated.

RESULTS

The most important matter we estimated was the efficiency of microbiological air decontamination using MFI method. In the examination a combination of microorganisms, differing with morphology and size of cell (from 0,5-10 µm) was used. Among them there were some bacteria, and conidiospores, either commonly appearing (Micrococcus, Bacillus, Staphylococcus, Aspergillus), or characteristic for hospital specific spaces, e.g. Pseudomonas aeruginosa in bio-aerosol exhausted by patients with respiratory tract infection.
The results of the examination were presented in Tables 1 and 2. They indicate a high efficiency of air cleaning measured on the example of device working in MFI technology. Even in the first of testing times there was a visible and significant decrease of microorganism quantity. Only singular cells of Micrococcus luteus, Bacillus subtilis, and Asperglillus niger were found in exhausted air, flowing out of the air cleaning tunnel, soon after spreading the inoculum in air. These microorganisms were found in samples taken directly after polluting the air. In spite of this in all the following measurements (15 min., 1, 3, 24 h) no test strains of bacteria, were isolated in exhausted air. It proves a constant effectiveness of air cleaning MFI method, regardless the time of exposure, or quanity of microorganisms in room space (Table 1).

Table 1.
The effectivenes of air cleaning MFI method, presented on device – Nanobio E 310

Microorganism cfu	The amount of microorganisms in air exhausted from the device (cfu/m^3)				
	The period of defice`s work				
	0**	15 min	1 h	3 h	24 h
Staphylococcus aureus N_0 = 3,9 x 10^7	< 1	< 1	< 1	< 1	< 1
Micrococcus luteus N_0 = 4,9 x 10^7	8,3	< 1	< 1	< 1	< 1
Escherichia coli N_0 = 6,7 x 10^8	< 1	< 1	< 1	< 1	< 1
Serratia marcescens N_0 = 7,3 x 10^7	< 1	< 1	< 1	< 1	< 1
Pseudomonas aeruginosa N_0 = 8,6 x 10^8	< 1	< 1	< 1	< 1	< 1
Bacillus subtilis N_0 = 3,4 x 10^7	6,25	< 1	< 1	< 1	< 1
Candida albicans N_0 = 7,9 x 10^7	0	< 1	< 1	< 1	< 1
Aspergillus niger N_0 =4,5 x 10^8	6,25	< 1	< 1	< 1	< 1

* - *aerozol – featured inoculum introduced to the intakes of air (suction elements of the device)*

cfu – colony forming unit

** - *sampling close to the exhaust of air the device (from inner tunnel) – the unit of sampling time F, the time of sampling 320 s, the volume of tested air: 0,48 m^3*

The total amount of microorganisms in 1 m^3 of air cleaned in the device Nanobio E 310 was lower than 1 cfu/m^3. Such value is adequate to the requirements of most of present microbiological cleanness norms, destined to operation rooms, e.g. DIN – 1946, US Fed Stand 209 P. The analogical level of microbiological cleaning (< 1 cfu/m^3) is obligatory for aseptic work rooms in pharmaceutical factories, and also in microbiological laboratories, e.g. Laminar air flow cabinet (LAF), used for testing the sterility and microbiological cleanness of pharmaceutics (2).

Table 2.
The identification of test strains in the air of the testing room, during examination (sedimentation method)

Microorganism	The period of device`s work				
	Sampling place	0*	1 h	3 h	24 h
Staphylococcus aureus ATCC 6538	A	+++	0	0	0
	B	0	0	0	0
Micrococcus luteus ATCC 9341	A	+++	0	0	0
	B	0	0	0	0
Escherichia coli ATCC 25922	A	+++	0	0	0
	B	0	0	0	0
Serratia marcescens ATCC 8100	A	+++	0	0	0
	B	0	0	0	0
Pseudomonas aeruginosa ATCC 27853	A	+++	0	0	0
	B	0	0	0	0
Bacillus subtilis ATCC 6633	A	+++	0	0	0
	B	0	0	0	0
Candida albicans ATCC 10231	A	+++	0	0	0
	B	0	0	0	0
Aspergillus niger ATCC 16404	A	+++	0	0	0
	B	0	0	0	0

Sampling:
A – close to the air intakes of device
B – 1 m from the floor level
** - in the time of introducing the bacterial inoculum to the device*
+++ - flowing growth on Agar plates (not countable colonies)
0 – no growth

The results presented in Table 2 indicate, that the device working according to MFI technology near the source of biological aerosol contamination will restrict its spreading around, in the environment. In our examination, strains of bacteria used for testing were detected only in the very first moment and a place of dosing the inoculum to the air (time 0 and, ground level at the input of air). These microbes were not detected in any of samples taken in further time (1, 3, 24 h), and place of examination (1 m above the ground level).
It needs to be emphasized, that after completing the cycle of testing there were no living organisms (bacteria, fungi) in the inner surface of device`s tunnel, where the proccess of air cleaning takes place.
The results of the examination, reveal that MFI air cleaning technology can enable reaching an appropriate level of biological safety in many fields of human activities. Taking advantage of this technology might be particularly useful for:

- isolation rooms in hospitals for highly infective patients
- operation and post-operation halls
- aseptic boxes passages and gates
- BSL 1 - 4 laboratories destined for work with microorganisms
- places for producing pharmaceutics and their microbiological control

CONCLUSIONS:

1. Air cleaning using MFI method is effective against the wide spectrum of microorganisms and determines either their removal from air or their destruction.
2. Microbiological air purity after passing MFI air cleaning proccess (<1 cfu/m^3) is adequate to the highest air cleanness class, settled for health service institutions and pharmaceutical works.
3. The MFI technology of air cleaning enables reaching an appropriate level of biological safety for hospitals, laboratories, and industrial works.

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Author for correspondence:
Dr Zygmunt Muszyński, Department of Bacteriology, University of Medical Sciences, 61-771 Poznań, 10 Sieroca str., Poland, e-mail: zmuszyn@amp.edu.pl

Elimination Capacity of Genano 310 Air Purifyer relating to airborne Bacteria and Fungi

9. International Hygiene Congress, Berlin 22.04.2008, Johanna von Lipinski

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Laboratory Test

1. Test Organisms
2. Bacteria species
   - Escherichia coli
   - Pseudomonas aeruginosa
   - Stapylococcus aureus
3. Yeast species Candida albicans Fungi species Aspergillus niger

Laboratory Test Realisation

Fumigation of testgerms / fungi as fine aerosol (concentration 10^4-10^5 KbE/ml) into Genano 310

Sampling (100 l/ min) with an air sampler directly at the air outlet

Elimination Capacity of Genano 310 Air Purifyer relating to airborne Bacteria and Fungi

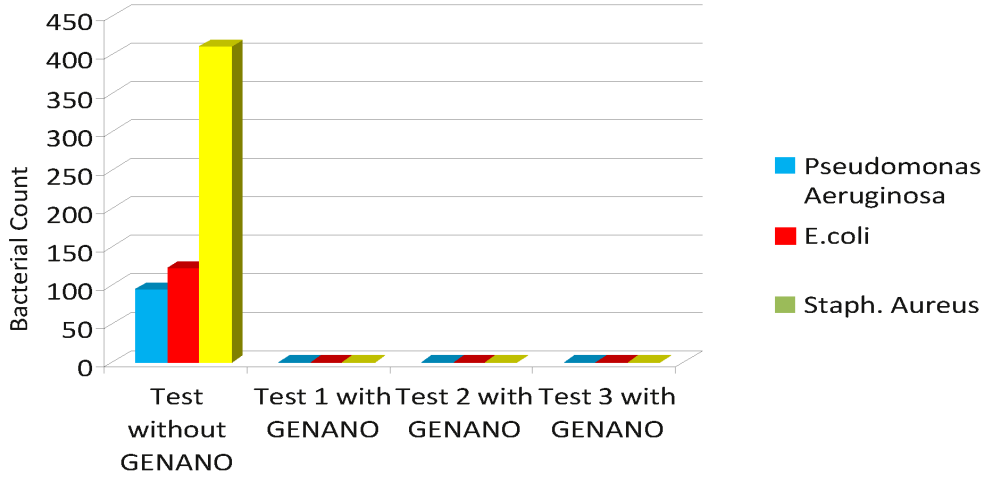
9. International Hygiene Congress, Berlin 22.04.2008, Johanna von Lipinski

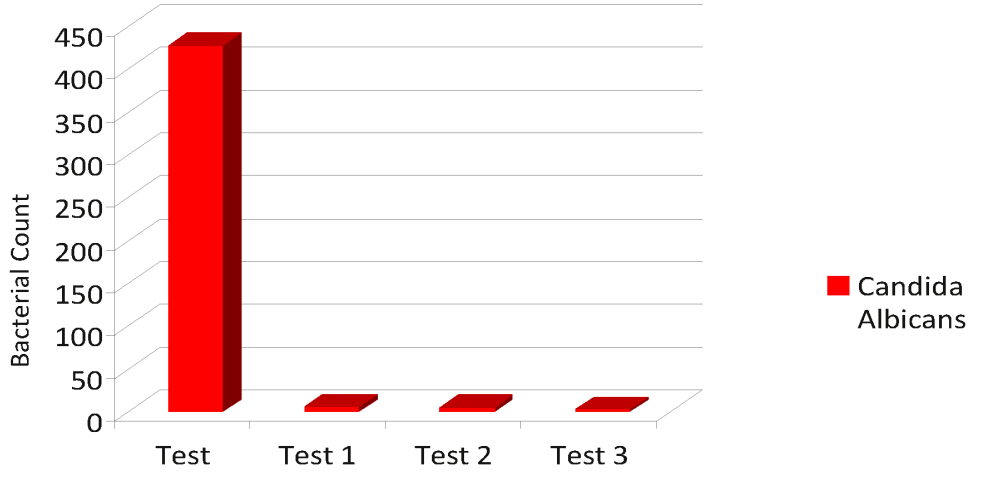
Laboratory Test Realisation

- 9 samples of every test germ
- Blank value: only air stream without fumigation

Prevalue:
only air stream with fumigation and a direct measurement and a measurement after 90 and 180 sec respectively after the first sampling
– 3 testings: air stream + ionisation with fumigation with a direct measurement and an after measurement after 90 and 180 sec respectively after the first sampling

Results Laboratory Test





Elimination Capacity of Genano 310 Air Purifyer relating to airborne Bacteria and Fungi

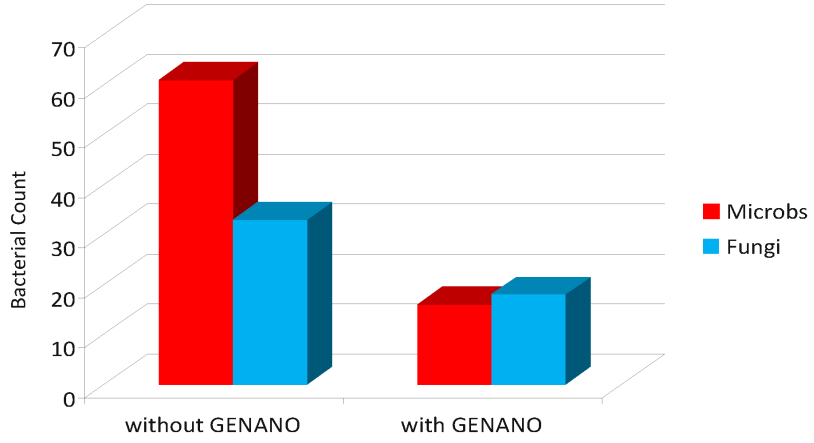
9. International Hygiene Congress, Berlin 22.04.2008, Johanna von Lipinski

Praxis Test Room Specification

- Cheese store in Marktkauf Greifswald
- Without windows
- Tiled cold room (appox. 4°C)
- Size approx. 40 m^3
- No connection to HVAC
- Several entrances per hour of personnel, otherwise door closed
- Daily sampling with an air sampler (250 l) each with agar and malt culture medium
- Starting with 6 days measurement proving the actual state
- Followed by 14 days measurement with working Genano 310 air purifyer
- Substitution of the single gasabsorber to a triple plate after 5 days, for a better ozon elimination

Results Praxis Test

Cheese store



EVALUATION OF "GENANO 310"

GENNAO310 is a system that is used for air disinfection.

The GENANO was evaluated for 12 weeks at King Fahad Medical City, Riyadh, for disinfecting the Microbiology, infectious serology and immunology laboratories; this is in addition to its use at the PRINTING department to remove ink particles generated during heavy duty printing.

All samples were evaluated before and after installing the machine. Air and environmental samples were incubated and cultured at 37 c for 48 hrs.

Feedback

1. The Machine is useful in killing all type of bacteria (Klebsiella, Enterobacter, Acinetobacter etc.) In addition, it can eliminate most of the viruses (respiratory) and respiratory borne pathogens.
2. It is safe and without any apparent biomedical hazards.
3. It helped in rapid cleaning of the lab & re-use in as short as 30 minutes.
4. Air Samples for fungal growth were collected before machine installation, after and during installation. Microbiological lab results reveal dramatic reduction of fungal growth to completely clean and sterile air.
5. Its use in TB labs increased safety of the laboratory.
6. The Dirty flush water basin was frequently checked, emptied and cleaned off the wastes. Swap Samples were taken from the collected waste, no growth found when incubated.
7. Technically the instrument uses the MFI technology, the latest and best technology in the market that can be used to remove all the types of particles and airborne microbes.
8. We highly recommend using the Air cleaner at hospital settings specially in infectious areas in the laboratory, in addition to infectious isolation rooms.

مدينة الملك فهد الطبية
إدارة علم الامراض والمختبرات الطبية
الادارة
Pathology & Clinical Laboratory Medicine
King Fahad Medical City

Dr GEYHAD ELGHAZALI
22/1/2012

Royal Hospital

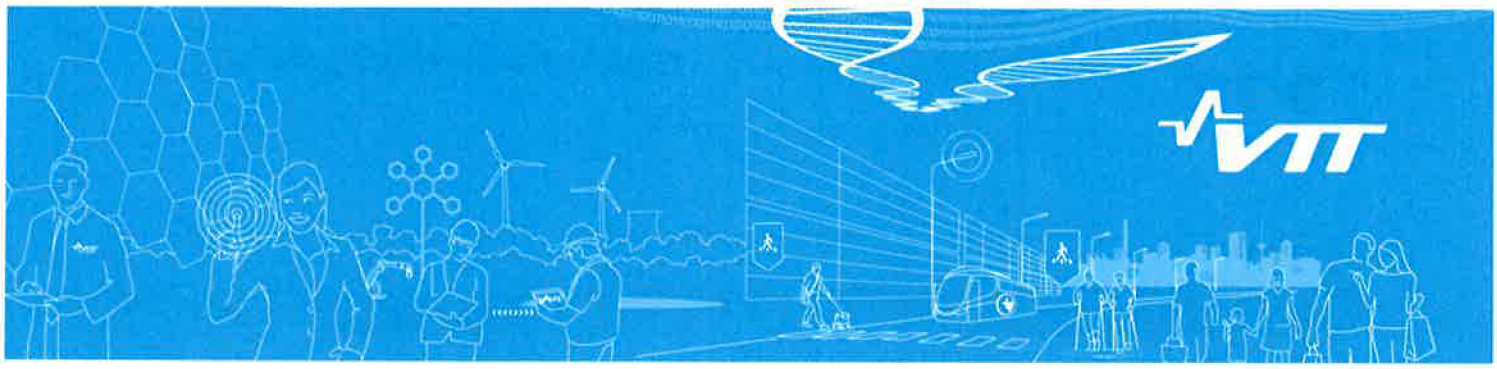
Infection Prevention & Control

Summary of Genano Mobile Filter Evaluation (SNW)

Date	Room No.	Pre-filter	24 Hours post filter	48 hours post filter
15.12.2014	7	Bacteria: heavy growth Fungus:> 50 cfu/m^3	Bacteria:17 cfu/m^3 Fungus: 0 cfu/m^3	(72 hours sample) No Bacterial & Fungus Growth
22.12.2014	14	Bacteria: 100 cfu/m^3 Fungus: 0 cfu/m^3	Fungus: 0 cfu/m^3 Bacteria: 0 cfu/m^3	No Bacterial & Fungus Growth
29.12.2014	2	Bacteria: 44 cfu/m^3 Fungus: 1 cfu/m^3	No Bacterial & Fungus Growth	No Bacterial & Fungus Growth
12.1.2015	8	Fungus: 4 cfu/m^3 Bacteria: 90 cfu/m^3	No Bacterial & Fungus Growth	No Bacterial & Fungus Growth
1.2.2015	5	Bacteria: 4 cfu/m^3 Fungus: 0 cfu/m^3	No Bacterial & Fungus Growth	No Bacterial & Fungus Growth

DR. ZAINAL MASKARI
SENIOR SPECIALIST
INFECTION PREVENTION & CONTROL
ROYAL HOSPITAL
4/3/15

Nanoscale Particle Purification



CUSTOMER REPORT

VTT-CR-03772-17
27.6.2017

Measurement of Genano 5250 air cleaner with ultrafine partilces

Authors: Sampo Saari

Confidentiality: **Confidential**

Report's title

Measurement of Genano 5250 air cleaner with ultrafine partilces

Customer, contact person, address	**Order reference**
Genano Oy Pasi Makkonen Metsäneidonkuja 6 02130 Espoo	
Project name	**Project number/Short name**
G5250 suorituskyvyn rap.	116318

Summary

The purpose of the study was to determine the filtration efficiency of Genano 5250 air cleaner for ultrafine particles.

The measurement was done with flow-through method at VTT air filtration laboratory. The test particles were generated by a nucleation mode particle generator developed by TUT aerosol physics laboratory and with a small diesel combustion engine. Filtration efficiency for ultrafine particles was determined by measuring the particle concentrations alternately from chambers upstream and downstream side of the cleaner with two scanning mobility particle sizers (Nano-SMPS and Long-SMPS, TSI Inc.).

According to the measurements, the filtration efficiency of the tested Genano 5250 air cleaner was between 75 - 98% depending on the air flow and the particle size.

Tampere 27.6.2017

Written by

Sampo Saari
Research Scientist

Accepted by

Aimo Taipale
Research Team Leader

VTT's contact address

Tekniikankatu 1, Tampere, Finland

Distribution (customer and VTT)

Pasi Makkonen, Genano Oy: 1 copy
VTT: 1 copy

1. Description and objectives

The purpose of the study was to determine the filtration efficiency of Genano 5250 air cleaner for ultrafine particles. The cleaner was supplied to VTT by the customer.

2. Methods / realisation

The measurements were made at VTT air filtration laboratory between 27.1. - 5.2.2016. The Genano 5250 air cleaner consisted of an electrostatic precipitator unit and a filter cassette. The air purifier was installed in the test system, which follows the principles of air filter test standard EN 779, see Figure 1. The air purifier was installed between two sealed chambers in such a way that inlet and outlet of the device were connected in different chambers. The pressure drop over the air purifier was adjusted to zero by using extra fans. In this way the conditions were similar compared to operating in open room space. The air flow values were measured with MR 100 flow measurement device which was calibrated with venture flow meter. The pressure drop was measured with micromanometer DPM TT 470S.

The filtration efficiency of the Genano 5250 air cleaner was measured with ultrafine particles generated by a nucleation mode particle generator developed by TUT aerosol physics laboratory and with a small diesel combustion engine. The test aerosol was mixed into HEPA filtered supply air. The fractional filtration efficiency was determined by measuring particle concentrations alternately from upstream and downstream of the air purifier. The particle size distributions were determined with two scanning mobility particle sizers (Nano-SMPS and Long-SMPS, TSI Inc.) covering particle size range between 5 – 200 nm. The efficiency was measured with three air flows corresponding to fan speeds 1, 2 and 3 of the purifier. The effect of dust loading on the filtration efficiency of the Genano 5250 was not measured in this study.

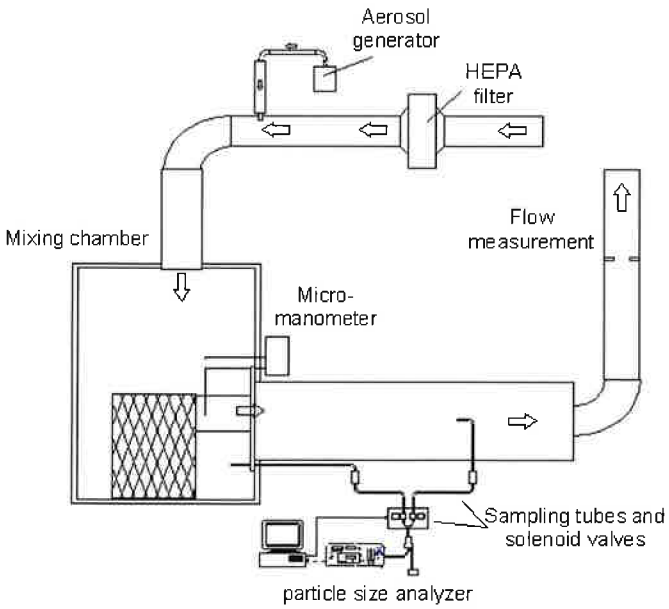


Figure 1. Principle of the test system.

3. Results

The air flow values of measured purifier Genano 5250 are shown in Table 1 and the filtration efficiency for ultrafine particles in Figure 2.

Table 1. Air flow with different fan speeds (1, 2 and 3), Genano 5250.

Genano 5250			
Fan speed	1	2	3
Air flow [m^3/h]	151	306	468

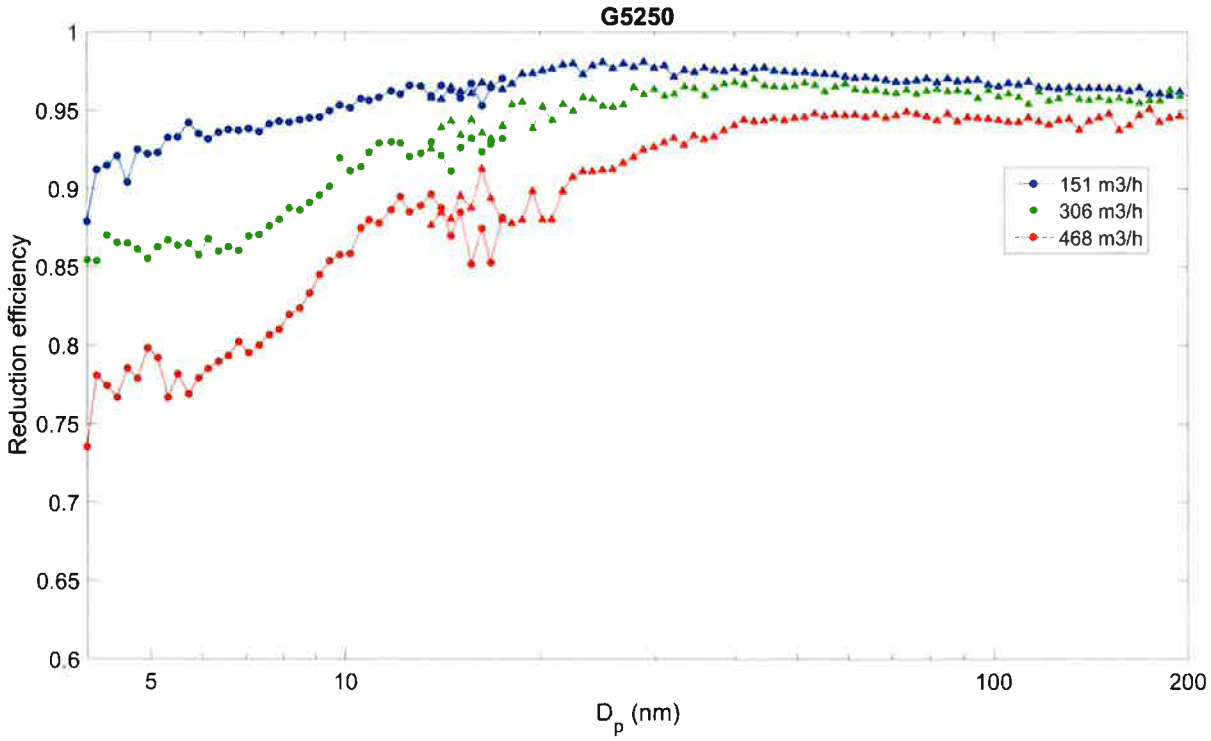


Figure 2. Efficiency of Genano 5250 air purifier for ultrafine particles. Dots represent Nano-SMPS data and triangles represent Long-SMPS data.

EPITEK OY
Epitek Oy
Urheilutie 40
40800 VAAJAKOSKI
040-5511 299
jorma.kokkonen@epitek.fi

METERING REPORT

31.05.2013

Jussi Erkkilä
Genano Oy
Kimmeltie 3
02110 ESPOO

Cleanroom classification and recovery time meterings were performed in the ASTQ's lightweight structure test room at 28th May, 2013.

The samples for the cleanroom classification were taken at approximately 1 m above ground from 10 sampling point locations, which were distributed evenly throughout the room. Also, a classification with the minimum sampling point locations dictated by the ISO 14644-1 standard was performed. This classification requires minimum number of five sampling point locations with the area of 17.5 m^2.

The test room meets the requirements of following classes, when the meterings are performed according to the SFS-EN ISO 14644-1:2000 standard:

ISO class 6; at rest, 0.5 µm, (5 sampling locations, 95 % UCL)
ISO class 6; at rest, 0.5 µm, (10 sampling locations, the mean of values)

Chart 1, Classifications

	particles / m^3	**ISO-class**	**ISO-class limit particles / m^3**	**Sampling locations**
0.5 µm	13 570	6	35 200	5
0.5 µm	10 725	6	35 200	10

For the recovery time metering Alron Chemical CO AB's test smoke was produced into the room with Magnum Thermo Fogger. After reaching the limit of more than 10^5 particles per m^3, 1 minute samples were taken with the particle counter until the decrease of ≥ 0.5 µm particles was noticed. Sampling was continued until the amount of ≥ 0.5 µm particles was reduced to the hundredth part of the starting value. The recovery time was 13 minutes.

The starting values and amounts of ≥ 0.3 µm and ≥ 0.5 µm particles are collected into the chart 2 as particle concentrations per m^3, until the concentration of ≥ 0.5 µm particles was reduced first time below the hundredth part of the starting value.

Chart 2; Recovery time measurements

Time	particles / m^3 ≥ 0.3 µm	particles / m^3 ≥ 0.5 µm	Recovery time ≥ 0.5 µm (min)
Starting value	20 655 724	9 703 617	---
1 min	14 243 656	3 260 061	---
2 min	11 457 321	2 036 104	---
3 min	8 957 270	1 395 092	---
4 min	6 823 632	991 048	---
5 min	5 299 801	727 639	---
6 min	4 094 130	524 029	---
7 min	3 150 172	397 231	---
8 min	2 491 369	300 721	---
9 min	1 947 572	228 321	---
10 min	1 515 288	168 240	---
11 min	1 187 845	133 823	---
12 min	939 828	100 817	---
13 min	735 829	78 684	13 min

A description with both 0.3 µm and 0.5 µm particle concentrations as an appendix.

Measuring apparatus (devices are calibrated annually, calibrations valid until December 2013, certificate of calibration as an appendix):

Particle-counting device (calibrated 28th December, 2012)
MET ONE LASER PARTICLE COUNTER 3313

- sample volume 1 ft^3 in 1 minute
- 0.3, 0.5, 1.0, 3.0 5.0 and 10.0 µm particles can be determined

Best Wishes,

Jorma Kokkonen

Epitek Oy

Measurement of Genano 310 P Air Cleaner

Customer: Genano Oy

VTT INDUSTRIAL SYSTEMS

Requested by	Genano Oy Teknobulevardi 3-5 01530 Vantaa
Order	2.5.2005 / Juha Santasalo
Handled by	Research Scientist Aimo Taipale, VTT Industrial Systems, P.O. Box 1307, FI-33101 Tampere, Tel. +358 20 722 5454, +358 40 836 5798, fax +358 20 722 3782, email: Aimo.Taipale@vtt.fi.

Measurement of Genano 310 P Air Cleaner

Time	8.-9.6.2005.
Target	Air cleaner Genano 310 P supplied by the customer.
Contents	This study included measurements of air flow and fractional filtration efficiency of the air cleaner.
Methods	The measurements were made with a test system the principle of which is shown in Figure 1. The air cleaner was installed in the test system which follows the principles of air filter test standard EN 779. The measurement was performed by utilizing the flow-through method. The air cleaner was installed between two sealed chambers in such a way that inlet and outlet of the device were connected in different chambers. The pressure drop over the air cleaner was adjusted to zero by using extra fans. In this way the conditions were similar compared to operating in open room space. The air flow values were measured with MR 160 flow measurement device which was calibrated with venturi flow meter. The pressure drop was measured with micromanometer DPM TT 470S. The fractional filtration efficiency was measured with DEHS (di-ethyl-hexyl-sebacate) test aerosol generated with a pneumatic aerosol nebulizer. The test aerosol was mixed into HEPA filtered supply air. The fractional filtration efficiency was determined by measuring particle concentrations alternately from upstream and downstream of the air cleaner. The particle size distributions were determined with an optical particle size analyzer PMS LAS-X and in the size range of 0.15 - 5 µm.

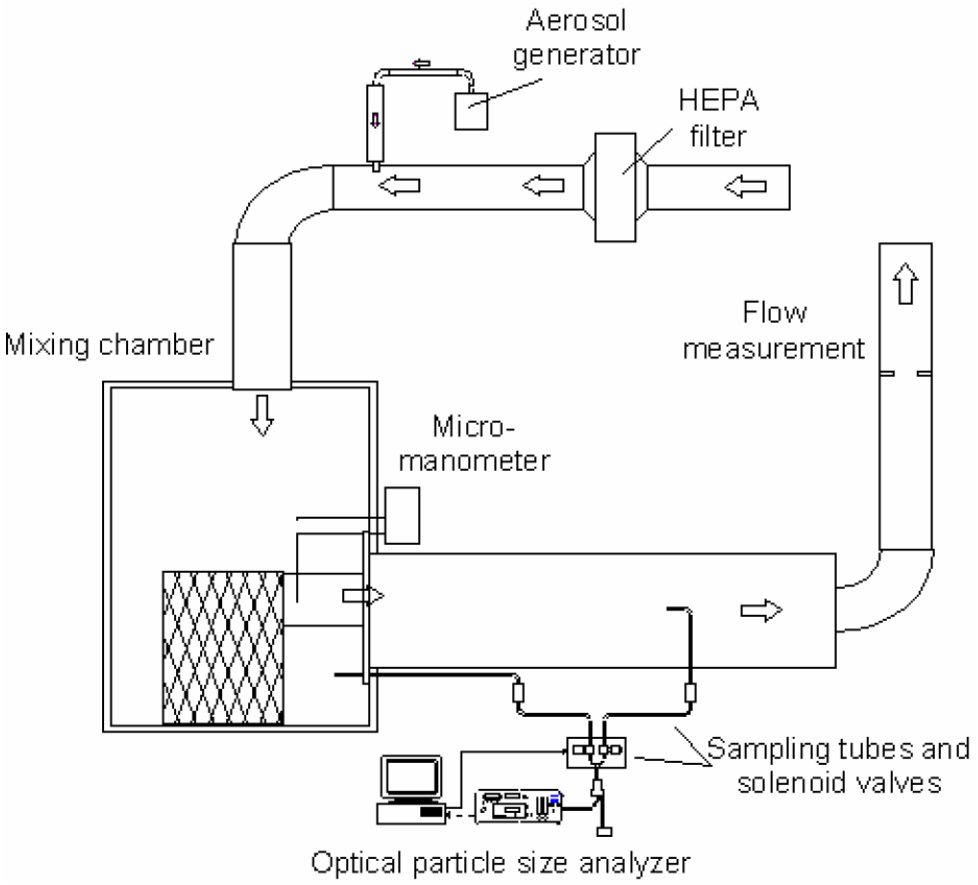


Figure 1. Principle of the test system.

The fractional removal efficiency E(dp) was calculated by

$$E(d_p) = 100 * \left(1 - \frac{C_2(d_p)}{C_1(d_p)}\right),$$

where C1(dp) is the upstream and C2(dp) the downstream concentration corresponding to the particle size dp.

Results

The air flow values of the air cleaner are presented in table 1. The fractional filtration efficiency is presented in table 2.

Table 1. Air flow values

Fan speed	Air flow (m^3/h)
1	100
2	150
3	180

Table 2. Fractional filtration efficiency (%)

d_p(µm)	Speed 1	Speed 2	Speed 3
0.13	99.5	99.0	98.0
0.16	99.6	99.1	98.1
0.20	99.6	99.0	97.9
0.28	99.7	99.0	98.1
0.39	99.7	99.2	98.6
0.51	99.7	99.4	98.6
0.67	99.7	99.5	98.9
0.87	99.8	99.7	99.1
1.22	99.8	99.7	99.5
1.73	99.8	100.0	99.7
2.45	100.0	100.0	100.0
3.67	100.0	100.0	100.0
5.20	100.0	100.0	100.0

Tampere, 26.9.2005

Senior Research Scientist Arto Säämänen

Research Scientist Aimo Taipale

Appendices - pc

Distribution

Customer 1 kpl
VTT Industrial Systems 1 kpl

DNA Measurement

Customer: Genano Oy

Requested by	Genano Oy Teknobulevardi 3-5 01530 Vantaa
Order	14.11.2005 / Juha Santasalo
Handled by	Research Scientist Reetta Satokari, VTT , P.O. Box 1500, FI-, Tel. +358 20 7225231, fax +358 20 7227071 , email: reetta.satokari@vtt.fi.

DNA Measurement

Time	24.11.-14.12.2005.
Target	Genano Air cleaner 310 supplied by the customer. The model was stripped off its carbon filter.
Contents	This study included measurements of filtration efficiency for DNA molecules. The filtrations were done at the VTT Industrial Systems (Tampere) with Dr. Aimo Taipale as the person in charge and the DNA analytics in VTT Biotechnology (Espoo) with Dr. Reetta Satokari as the person in charge.
Methods	The measurements were made with a test system the principle of which is shown in Figure 1. The measurement was performed by utilizing the flow-through method. The air cleaner was installed between two sealed chambers in such a way that inlet and outlet of the device were connected in different chambers. The air flow through the air cleaner was arranged by extra fans. The air flow values were measured with MR 100 flow measurement device which was calibrated with venturi flow meter. The pressure drop was measured with micromanometer DPM TT 470S. A 264 bp DNA-fragment was produced by using polymerase chain reaction (PCR) and purified with QIAquick PCR Purification Kit (Qiagen GmbH, Germany) according to the manufacturers instructions. The DNA containing particles were generated with a Laskin -type particle generator. The test aerosol was mixed into HEPA filtered supply air. The filtration efficiency was determined by comparing DNA concentrations downstream of the air cleaner when the high voltage was turned on and off. The concentrations were determined with filter sample method and qPCR (see below). The particles were collected with Nuclepore 0.4 um sample filters.

The air cleaning device was washed after the particle collection period by automatic washer included in the device. Also the DNA concentration of the washing liquid was determined by qPCR.

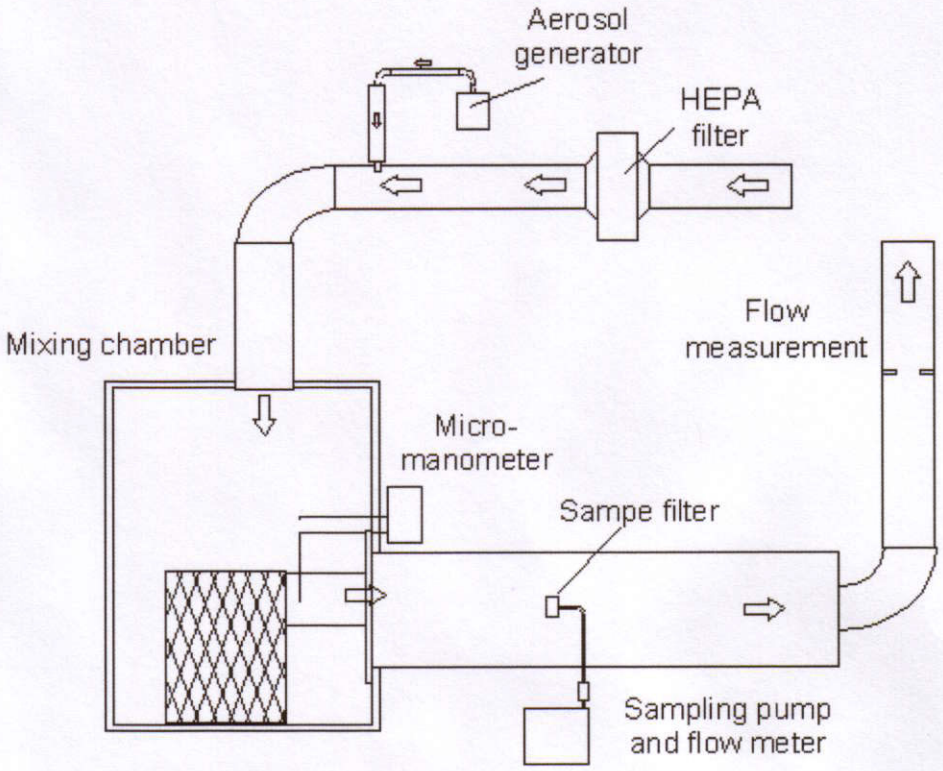


Figure 1. Principle of the test system.

The DNA concentration was determined by quantitative PCR (qPCR) by using LightCycler quantitative PCR machine (Roche Diagnostics, Penzberg, Germany) and SYBR Green reaction chemistry (DyNAmo Capillary SYBR Green qPCR Kit, Finnzymes, Espoo, Finland). The sample filters were immersed in 4 ml of TE-buffer (10 mM TRIS, pH 8.0 – 1 mM EDTA) and vortexed vigorously. One microliter thereof was used for qPCR analysis. Also one microliter of the washing liquid was used for qPCR analysis. The qPCR analysis was done in dublicate. The results were calculated using an external standard curve, which was included in the run. The melt curves of the products were checked in order to verify that a correct product was amplified.

Results

The filtration efficiency (E) was determined from DNA concentrations downstream of the air cleaner when the high voltage was turned on and off: samples 1, 5 and 7 were compared to the sample 4 and the sample 2 to the sample 3 (Table 1).

The filtration efficiency (E) was calculated by
$E = 100 * (1 - C_{on}/C_{off})$,
where C_{on} is the high voltage on concentration and and C_{off} is the high voltage off concentration.

The quantification of very low concentrations of DNA (~1E+01 per microliter and below) is inaccurate and therefore concentrations at low level must be interpreted with caution. Only fold-changes in the DNA quantity are meaningful herein. Further, the filtrated air volumes differed slightly in high-voltage-on and high-voltage-off samples. Therefore, the obtained E-values are indicative. In order to obtain reliable E-values repeated testing is needed.

Table 1.

Test no	High voltage	Stream of air (m3/h)	Volume (dm^3)	Sample suspension volume (ml)	DNA concentration (molecules / microliter)			E
					1	2	Mean	
1	on	80	426 (air)	4	8,2E+00	1,9E+00	5,1E+00	99,97
2	on	150	785 (air)	4	8,3E+01	7,0E+01	7,7E+01	99,71
3	off	150	796 (air)	4	2,5E+04	2,9E+04	2,7E+04	
4	off	80	404 (air)	4	2,0E+04	1,8E+04	1,9E+04	
5	on	80	447 (air)	4	1,0E+01	7,1E+00	8,6E+00	99,95
6	*		2 (water)		1,7E+02	1,5E+02	1,6E+02	
7	on	80	401 (air)	4	0,0E+00	3,6E+00	1,8E+00	99,99
8	*		1 (water)		5,1E+02	5,6E+02	5,4E+02	

* The washing liquid was collected after the run of the tests no 1-5 (test 6) and after the test no 7 (test 8).

The DNA-fragments removed from cleaned flow-through air were detected in the washing liquid and the total DNA quantity of the washing liquids was in the level that corresponded to the DNA quantity removed from the air during the flow-through (Table 2).

Table 2.

Test no	High voltage	Stream of air (m3/h)	Volume (dm^3)	Sample suspension volume (ml)	Total DNA (molecules)
1	on	80	426 (air)	4	2,0E+04 / filter
2	on	150	785 (air)	4	3,1E+05 / filter
3	off	150	796 (air)	4	1,1E+08 / filter
4	off	80	404 (air)	4	7,6E+07 / filter
5	on	80	447 (air)	4	3,4E+04 / filter
6	*		2 (water)		3,2E+08 / 2 l water
7	on	80	401 (air)	4	7,2E+03 / filter
8	*		1 (water)		5,4E+08 / 1 l water

* The washing liquid was collected after the run of the tests no 1-5 (test 6) and after the test no 7 (test 8).

14.12.2005

Richard Fagerström, PhD
Senior Research Scientist

Reetta Satokari, PhD
Research Scientist

Distribution Customer 1 kpl
VTT Biotechnology 1 kpl

TYÖTERVEYSLAITOS
INSTITUTET FÖR ARBETSHYGIEN
FINNISH INSTITUTE OF OCCUPATIONAL HEALTH

Testing of an air cleaning instrument -the aerosol particle filtration efficiency

Tested item	**Multifunction-Ion Air Cleaning**
Type	**Nanobio E310**
Serial number	**3100027**
Customer	**Genano Oy ltd** **Sinikellonpolku 3** **FIN-01300 Vantaa** **Finland**
Applied methods	**Differential Mobility Particle Sizer** **Optical Particle Counter** **Condensation Particle Counter** **Ozone monitor, Method EQOA-0383-056 (U.S.E.P.A.)**
Results	**The size fractionated aerosol particle filtration efficiency between 0.003 µm and 10 µm.** **Total aerosol particle filtration efficiency.** **Ozone production.**

Kaarle Hämeri
Professor

Ismo Koponen
Researcher

■ Topeliuksenkatu 41 a A, 00250 Helsinki ☎ 09-47 471
Topeliusgatan 41 a A, 00250 Helsingfors fax 09-24 14 634
■ Laajaniityntie 1, 01620 Vantaa ☎ 09-47 471
Bredängsvägen 1, 01620 Vanda fax 09-890 713
■ Arinatie 3, 00370 Helsinki ☎ 09-47 471
Ärilsvägen 3, 00370 Helsingfors fax 09-556 157

■ Topeliuksenkatu 41 a A ☎ +358-9-47 471
FIN - 00250 Helsinki fax +358-9-24 14 634
■ Laajaniityntie 1 ☎ +358-9-47 471
FIN - 01620 Vantaa fax +358-9-890 713
■ Arinatie 3 ☎ +358-9-47 471
FIN - 00370 Helsinki fax +358-9-556 157

1. Description and identification of test items

Test item Multifunction-Ion Air Cleaning

Type Nanobio E310

Serial number 3100027

Manufacturer Genano Oy ltd

2. Scope of testing

The customer supplied the air cleaning instrument at December 2002. The filtration efficiency was determined by measuring the size distributions and total particle number concentrations both at the air inlet and outlet using a valve system. The filtration efficiency was measured for ambient aerosol particles between 0.003 μm and 0.5 μm using two Differential Mobility Particle Sizers (DMPS). Filtration efficiency for particles between 0.5 μm and 10 μm was measured using an Optical Particle Counter (OPC, Climet CI-500). Total filtration efficiency for aerosol particle number concentration was measured using a Condensation Particle Counter (CPC, 3025 TSI Inc.). The ozone production was measured using an ozone monitor (Dasibi Environmental corp., Model 1008-AH).

The tests were performed at the aerosol laboratory of the Department of Physical Sciences of the University of Helsinki. The experiments were carried out at normal room temperature (22°C +/- 1°C), relative humidity (RH 10% +/- 5%), and total pressure (1003 +/- 3 hPa).

The test instrument has three flow settings (flow 1=0.3 m/s, flow 2=0.5 m/s, and flow 3=1 m/s). The aerosol particle filtration efficiency was tested for all flow settings. The ozone production was tested for the flow 1 setting.

The filtration efficiency results include experimental uncertainty, which was estimated +/-10% in the individual concentration values at CPC and DMPS readings, which was considered in the efficiency results.

3. Test result

3.1 Aerosol particle filtration efficiency

The size fractioned filtration efficiency for aerosol particles between 0.003 μm and 0.5 μm was better than 99.5% for all particle sizes and all three flow settings.

The size fractioned filtration efficiency for aerosol particles between 0.5 μm and 10 μm was better than 99.5% for all particle sizes and all three flow settings.

Total filtration efficiency for the size range between 0.003 µm and 3 µm was better than 99.5% in all three flow settings.

3.2 Ozone production

The ozone production was 17.5 ppb (+/- 1 ppb) measured at the clean air outlet. The background concentration at the test room was less than 1 ppb during the test.

Investigation of the Performance of the Air Purifier in High-Risk Hospital Rooms by Counting Particles

*Mana Sezdi
*Istanbul University, Biomedical Device Technology, Istanbul, Turkey

Abstract

The air purifiers nowadays, are more preferred than the HEPA filters, because HEPA filters only eliminate the particles from the air, while the air purifier both removes particles without using any filter and gives cleaned-deionized air. Hence, it provides the more qualified air to the patient and health staff. The high-risk hospital rooms must be controlled by counting particles in according to the international standards,. The particles with sizes of 0,1µm, 0,2µm, 0,3µm, 0,5µm, 1µm, 5µm are counted and the measurement results are interpreted in accordance to the international standard; ISO 14644-1:1999(E) Cleanrooms and associated controlled environments Part 1: Classification of air cleanliness.
The objective of this study, is to test the performance of the air purifier in different room conditions. How much air is cleaned in how much time?
In the result, it was observed that the air purifier has cleaned the air efficiently, and it was obtained the optimum time relating to the total air volume for cleaning the room air. This study announces that the air purifiers are efficient solution to obtain clean air without particles in the high-risk hospital rooms. The primary advantage of this study would be that obtained knowledge in this area would lead to wide usage of air purifiers, and hence, to have more qualified air and to decrease the risk of infection in hospitals.

Key words: Air purifier, hepa filter, particle counting

1. Introduction

The quality of air is important in critical areas of hospitals such as operating rooms, intensive care units, bone marrow transplantation units etc, because of the particles. Particles are environmental pollutants that cause the risk of infection in hospitals [1]. But, it is possible to remove the particles from air by using HEPA (High efficiency particulate air) filter, or to clean the air by usingan air purifier [2-3]. Nowadays, the air purifiers are more preferred than the HEPA filters, because HEPA filters only eliminate the particles from the air, while the air purifier both removes particles without using any filter and gives cleaned-deionized air. Hence, it provides the more qualified air to the patient and health staff [2-3]. Although it is more expensive than HEPA filter system, it is preferred because the cost of it is less than the total cost to the hospital of a single nosocomial infection, taking into account additional days in the hospital, antifungal treatment and potential litigation costs.

The objective of this study, is to test the performance of the air purifier in a high-risk hospital room. The performance of the equipment is determined by counting particles that decrease during

*Corresponding author: Address: Biomedical Device Technology Istanbul University, 34320, Istanbul TURKEY. E-mail address: mana@istanbul.edu.tr, Phone: +902124737070 / 18557 Fax: +902124737079

operation of the equipment in the room [4-5]. The measurement results are interpreted to determine ISO class of the room in accordance to the international standard.

2. Materials and Method

The air purifier used in this study (Genano 310 Medical; Genano Oy, Espoo, Finland) is an certified medical device from The University of Greifswald Germany intended as a room air purifier/recirculating air cleaner and used for removing airborne particles from the air for medical purposes. The unit's physical dimensions are 1,46 m high 0,45 m wide 0,39 m deep, and its nominal operating range is 100-200 m^3/hour. It does not contain any filter, HEPA (High Efficiency Particulate Air) or ULPA (Ultra Low Penetration Air). The device works with the technology of multi ionized beams. The negatively charged particles in the air flow are projected onto the positively charged inner wall of the device. The wall is automatically rinsed at regular intervals. The inactivated residue is collected in a container at the foot of the unit.

The effectiveness of the Genano air purifier were tested in a bone marrow transplantation unit by placing it in different locations. The room area is 42 m^2 (7.2 m x 5.8 m) and hasn't got any hepa filter. To obtain 3 different location scenarios, the Genano unit was positioned firstly in the opposite corner of the bed (P1), secondly in the adjacent wall (P2), and thirdly near the bed's headboard (P3).

In this study, the particles in a patient room in bone marrow transplantation unit were firstly counted when the purifier was located in P1 position. The particle counter was placed onto the patient bed and the measurements were taken from the middle of the bed surface [6]. During measurement period, the particles were counted at each 1 minute in total 15 minutes. The results were stored and reported in the equipment automatically. The particle counter (Aerotrak Handheld Particle Counter 9306, TSI, USA) was used to count the particle sizes of 0,3 μm, 0,5 μm, 1,0 μm, 2,5 μm, 5,0 μm and 10,0 μm. The sampling air flow rate was 0,1 CFM (2,83 LPM) [7-9]. The personnel operating the equipment were clothed in body suits and face masks to prevent air contamination by them. The study was repeated in different days by operating the air purifier in other 2 different positions (P2 and P3) in the patient room. The measurement results were compared by considering the decontamination time. The classes of the patient room for 3 different positions of air purifier were determined in accordance to the ISO 14644-1 standardization.

2.1. Theory/calculation

The ISO 14644-1 standard is essential for the classification of clean room [10]. In according to the ISO 14644-1 standardization, the maximum permitted concentration of particles for each considered particle size is determined from the following equation [9-10]:

$C_n = 10^N \times (0,1 / D)^{2,08}$

C_n is the maximum permitted concentration (particles/m^3 of air)
N is the ISO classification number, which shall not exceed a value of 9.
D is the considered particle size, in micrometers and 0,1 is a constant.

The ISO classes and the corresponding particle concentrations (0,1µm, 0,2µm, 0,3µm, 0,5µm, 1µm and 5µm) can be seen in Table 1. In according to this standard, the mean particle concentration from each point must be equal to the limit particle concentration or lower.

Table 1. ISO Classification for Clean Room [10]

ISO Classification Number (N)	**Maximum concentration limits (particle/m^3 : in air)**					
	0,1 µm	**0,2 µm**	**0,3 µm**	**0,5 µm**	**1 µm**	**5 µm**
ISO Class 1	10	2	--	--	--	--
ISO Class 2	100	24	10	4	--	--
ISO Class 3	1 000	237	102	35	8	--
ISO Class 4	10 000	2 370	1 020	352	83	--
ISO Class 5	100 000	23 700	10 200	3 520	832	29
ISO Class 6	1 000 000	237 000	102 000	35 200	8 320	293
ISO Class 7	--	--	--	352 000	83 200	2930
ISO Class 8	--	--	--	3 520 000	832 000	29 300
ISO Class 9	--	--	--	35 200 000	8 320 000	293 000

The ISO class for operating room and intensive care unit should be ISO Class 5 for 0,3 micron or larger particle size, whereas it for patient room should be ISO Class 6 for 0,5 micron or larger particle size.

3. Results

The particle measurement results obtained from 3 positions and the corresponding ISO classes are shown in Table 2.

Table 2. Results of Particle Counting

Position	Sample ID	Concentration	ISO Spec.	ISO Class
Position P1	1, 04/10 /2014, 18:29:52	8 206 762	35 200 000	Class 9
	2, 04/10 /2014, 18:30:52	6 867 455	35 200 000	Class 9
	3, 04/10 /2014, 18:31:52	4 112 069	3 520 000	Class 9
	4, 04/10 /2014, 18:32:52	3 005 647	3 520 000	Class 8
	5, 04/10 /2014, 18:33:52	2 334 027	3 520 000	Class 8
	6, 04/10 /2014, 18:34:52	1 745 789	3 520 000	Class 8
	7, 04/10 /2014, 18:35:52	975 616	3 520 000	Class 8
	8, 04/10 /2014, 18:36:52	654 082	3 520 000	Class 8
	9, 04/10 /2014, 18:37:52	391 076	3 520 000	Class 8
	10, 04/10 /2014, 18:38:52	245 182	352 000	Class 7
	11, 04/10 /2014, 18:39:52	115 478	352 000	Class 7
	12, 04/10 /2014, 18:40:52	88 326	352 000	Class 7
	13, 04/10 /2014, 18:41:52	53 257	352 000	Class 7
	14, 04/10 /2014, 18:42:52	39 772	352 000	Class 7
	15, 04/10 /2014, 18:43:52	28 113	35 200	Class 6

Position P2	1, 04/12 /2014, 17:14:49	7 555 843	35 200 000	Class 9
	2, 04/12 /2014, 17:15:49	5 132 087	35 200 000	Class 9
	3, 04/12 /2014, 17:16:49	3 458 233	3 520 000	Class 8
	4, 04/12 /2014, 17:17:49	2 135 847	3 520 000	Class 8
	5, 04/12 /2014, 17:18:49	1 444 176	3 520 000	Class 8
	6, 04/12 /2014, 17:19:49	845 679	3 520 000	Class 8
	7, 04/12 /2014, 17:20:49	575 755	3 520 000	Class 8
	8, 04/12 /2014, 17:21:49	385 182	3 520 000	Class 8
	9, 04/12 /2014, 17:22:49	221 076	352 000	Class 7
	10, 04/12 /2014, 17:23:49	105 182	352 000	Class 7
	11, 04/12 /2014, 17:24:49	75 478	352 000	Class 7
	12, 04/12 /2014, 17:25:49	50 275	352 000	Class 7
	13, 04/12 /2014, 17:26:49	37 824	352 000	Class 7
	14, 04/12 /2014, 17:27:49	26 767	35 200	Class 6
	15, 04/12 /2014, 17:28:49	19 945	35 200	Class 6
Position P3	1, 04/14 /2014, 13:01:11	7 866 142	35 200 000	Class 9
	2, 04/14 /2014, 13:02:11	5 354 485	35 200 000	Class 9
	3, 04/14 /2014, 13:03:11	3 512 979	3 520 000	Class 8
	4, 04/14 /2014, 13:04:11	2 148 775	3 520 000	Class 8
	5, 04/14 /2014, 13:05:11	1 514 567	3 520 000	Class 8
	6, 04/14 /2014, 13:06:11	845 789	3 520 000	Class 8
	7, 04/14 /2014, 13:07:11	576 222	3 520 000	Class 8
	8, 04/14 /2014, 13:08:11	374 082	3 520 000	Class 8
	9, 04/14 /2014, 13:09:11	211 116	352 000	Class 7
	10, 04/14 /2014, 13:10:11	103 002	352 000	Class 7
	11, 04/14 /2014, 13:11:11	74 664	352 000	Class 7
	12, 04/14 /2014, 13:12:11	51 257	352 000	Class 7
	13, 04/14 /2014, 13:13:11	36 772	352 000	Class 7
	14, 04/14 /2014, 13:14:11	25 848	35 200	Class 6
	15, 04/14 /2014, 13:15:11	19 854	35 200	Class 6

4. Discussion

From the results obtained, it was evident that following the cleaning operation, the quality of the air is excellent in all position of the air purifier. When the measurement results are interpreted in accordance to the ISO classification, it is seen that the patient room was in ISO Class 9 for all positions initially because the number of particles were counted higher than 3 520 000. After the operating of the air purifier, the class of room decreased to ISO Class 6 that is accepted class for critical hospital rooms. The measured particle number was lower than 35 200.

Although same classification was obtained, a little difference in the particle count was found. The decontamination time is 12 minutes for P2 and P3 positions while it is 13 minutes for P1 position. As it is seen, the decontamination time in P2 and P3 positions is shorter than it in P1 position. The reason of this may be thought that P2 and P3 are near to the measurement point than P1 position. But it is not an important difference because the decontamination were performed in all positions perfectly. It was achieved that the initial ISO class is decreased to the acceptable ISO class in accordance to the international standard.

Conclusions

In the result, it was observed that the air purifier have cleaned the air efficiently, and it was obtained the optimum time relating to the total air volume for cleaning the room air. The measured decontamination time of 12-13 minutes are sufficient to clean room. This study announces that the air purifiers are efficient solution to obtain clean air without particles in the high-risk hospital rooms. This is suggested that the volume of room should be considered during decision of the number of air purifiers that will be worked, and the air purifiers should be replaced near the patient beds.

The primary advantage of this study would be that obtained knowledge in this area would lead to wide usage of air purifiers, and hence, to have more qualified air and to decrease the risk of infection in hospitals. The air purifiers, nowadays, are competitor to the Hepa filters. But, it is thought that in the future they will be preferred completely instead of Hepa filters.

Acknowledgements

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